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Title: Detecting Internal Decay in Trees Using Sonic Tomography Technology

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Description:

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Full paper: Attached here

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Detecting Internal Decay in Trees Using Sonic Tomography Technology

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Abstract

Picus Sonic Tomography Technology is the latest state-of-the-art instrument that can be used to assist arborists, tree care and urban forestry professionals in detection of internal decay in trees. This paper introduces the instrument and illustrates how it works using water oak (*Quercus nigra* L.) as an example. Picus Sonic Tomography Technology can be an effective tool in identifying hazardous trees and conducting risk assessment in urban and community forest management.

Picus Sonic Tomography Technology

Picus Sonic Tomography Technology (Argus Electronics GmbH, Rostock, Germany) is a noninvasive method to quantify and locate damaged wood or decay in trees. It is the latest state-of-the-art technology that produces color images of the internal structure of tree trunks in 2-D and 3-D tomography images by recording the speed difference of sound wave transmission throughout the trunk.

The technology has been studied and applied in urban forestry and arboriculture practice, proving to be effective in identification of tree internal decay and damage (Gilbert and Smiley, 2004; Göcke and Rust, 2007; Wang and Allison, 2008).

The principle is based on that sound waves move more slowly through decay wood than through the solid wood. The instrument measures time and distance of sonic waves traveling through the wood, calculates the velocity of the sound, and presents the velocity in the form of a tomography image, showing the location and degrees of solid and damaged wood by different colors and percentages.

The basic color correspondence to types of wood can be summarized as follows: **solid wood -** shown in black/dark brown/brown color; **transitional wood** – shown in green color, transitional means the portion of wood falling between the solid and damaged wood; and **damaged/decay wood** – shown in purple/blue/white color (Figures 1, 2).

Water oak

Water oak (*Quercus nigra* L.) is a shade tree commonly found along the coastal plains from Southern New Jersey to Florida to eastern Texas.

The water oak grows fast but has a relatively short life (60 to 80 years) in comparison to other oak tree species. It is a tall slender tree that reaches 50' to 80' in height. It is semi evergreen in some parts of the region but is completely deciduous in other locations (Carey, 1992). The leaves of the water oak remain on the tree during the winter, but fall before the spring (Miller and Lamb, 2003).

Water oak trees more than 2ft (60 cm) in diameter at breast height are often rotten in the center and partially hollow (Christman, 2007). Many mature water oak trees develop extensive internal decay and cavities in trunks and roots, becoming susceptible to hurricanes and storms (Figure 3).

During Hurricanes Andrew and Katrina, many water oak trees were uprooted and caused property damage more than any other tree species in Louisiana. Many mature water oak trees existing today are still posing potential hazards to the public. The purpose of this paper is to illustrate how Picus

Sonic Tomography technique can be used to detect internal decay in mature water oak trees.

Materials and Methods

Picus Sonic Tomography technology (Argus Electronics GmbH, Rostock, Germany) in conjunction with visual assessment was used to evaluate 10 mature water oak trees on Southern University's campus in Baton Rouge, Louisiana (Figure 4). The trees were given an ID number from 1-10.

Tree #1 was measured at four height levels (15, 80, 130, 165cm) above the ground due to its large cavity presented at the basal level while the remaining nine trees were measured at three height levels (30, 90, and 150cm) above the ground.

Eight to 12 Picus sensors were equally spaced around the tree trunk depending on the size of the trees using a strap wrap around the trunk to hold them in place. Roof nails (1-1.5 inches) were used to hammer through the bark into the sapwood (xylem) horizontally. The receiving sensors were then attached to the corresponding nail magnetically.

The trunk circumference was measured at each measurement level, and the average diameter of the trunk was calculated based on the circumference divided by π.

A free shape caliper was used to retrieve the size and physical shape (geometry) data of the tree using the Picus software and Targus Bluetooth technology. The exact shape of the trunk was obtained by measuring several distances between the measuring points.

The measurement was based on the geometric law: "A triangle can be constructed if the length of all three sites is known." Therefore, by using a three baseline method, the actual shape of the tree was transmitted onto the computer screen. After the tree's geometry was taken, each sensor attached to the nail at an individual point was tapped a minimum of three times, transmitting sound waves to the remaining sensors.

Upon completion of this process, the data were combined with the free-shaped caliper image to display the percentages of damaged, transitional, and solid wood in the tomography images generated from the Picus Sonic Tomography technology.

This procedure is repeated for each tree at each level. Dell GPS Navigation System (version A01NA) was used to acquire the latitude and longitude of each tree location and remarks were noted by visual assessment.

For each tree, the individual tomography images at different levels were compared and combined to construct the three dimensional images in various directions. Data were analyzed using Microsoft Excel and basic statistics.

Results and Discussions

Tomography images of 31 trunk cross-sections with diameters ranging from 43-121cm were obtained from 10 water oak trees in Baton Rouge, Louisiana. Two and three dimensional tomography images and decay patterns were obtained. Tree internal structures were visualized. The example of tree #1 is illustrated in Figure 4.

Of the 31 trunk cross-sections measured, twenty-four (77% of total samples) were found to have decay with percentages ranging from 1-70% on the area basis, and all ten trees measured appeared to have some degree of decay in at least one of the measurement levels.

Data suggested decay appears to be a common problem in water oak. Decay at the root/trunk interface may attribute to root rotten disease; perhaps repeated improper pruning practices in the earlier days of the tree's life may play a significant role in increasing trunk decay occurrences. Water oak rot unaffected by pruning techniques seems to initiate from the base of the tree and extends to the trunk above.

In summary, Picus Sonic Tomography technology is a useful tool in visualizing and detecting internal decay in tree trunks. The instrument will help arborists, urban forestry tree care professionals, and homeowners make informed decisions about tree health care and hazardous tree assessment. By incorporating the tomography information into traditional arboricultural practices, the accuracy of tree care should be enhanced

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Detecting tree internal structure using the Picus sonic tomography technology by SU urban forestry professor Dr. Yadong Qi and student Ms. Brittany Foster, in Baton Rouge, LA, USA

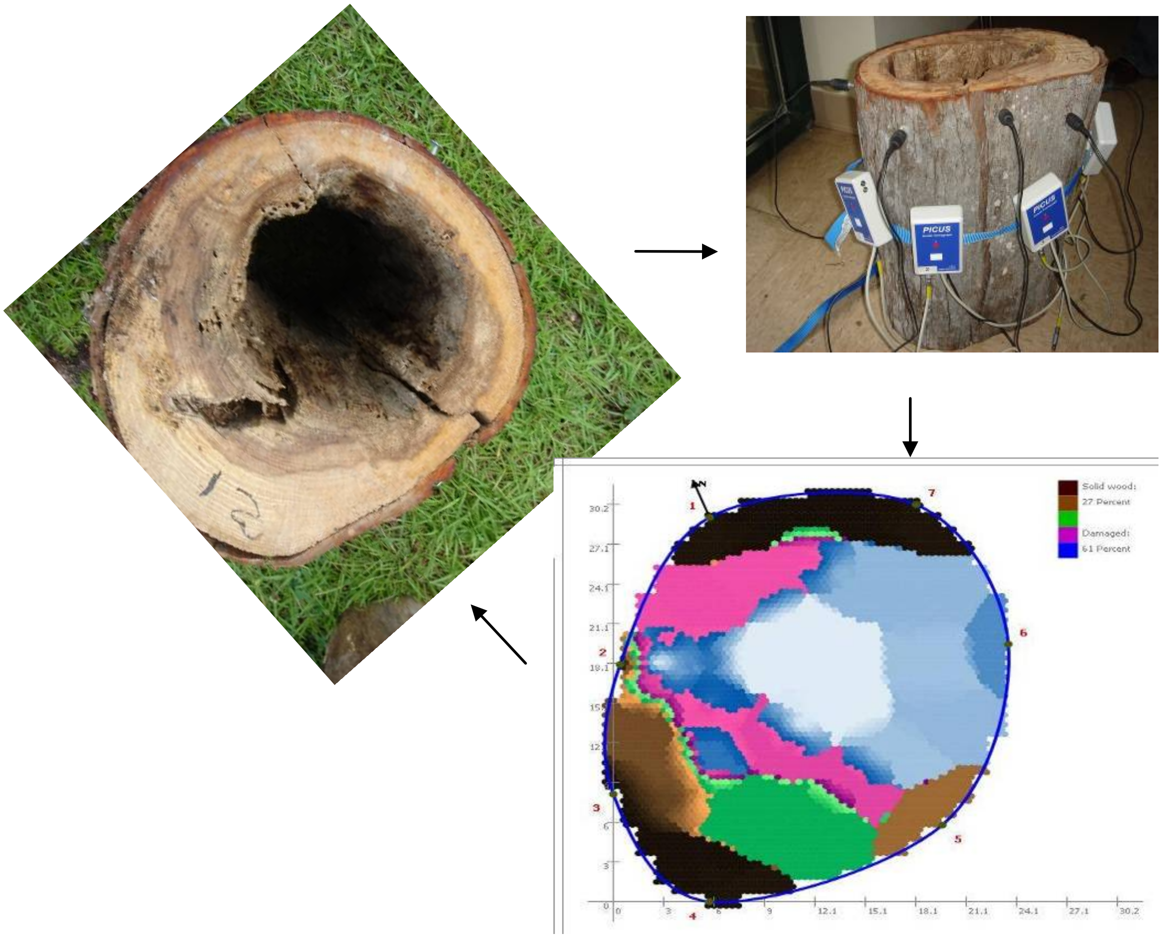


Figure 1. An example of a test stump showing how the Picus Sonic Tomography technology works. The image shows 61% decay wood (white, blue, and purple colors), 27% solid wood (black and brown colors), and 12% transitional wood (green color).

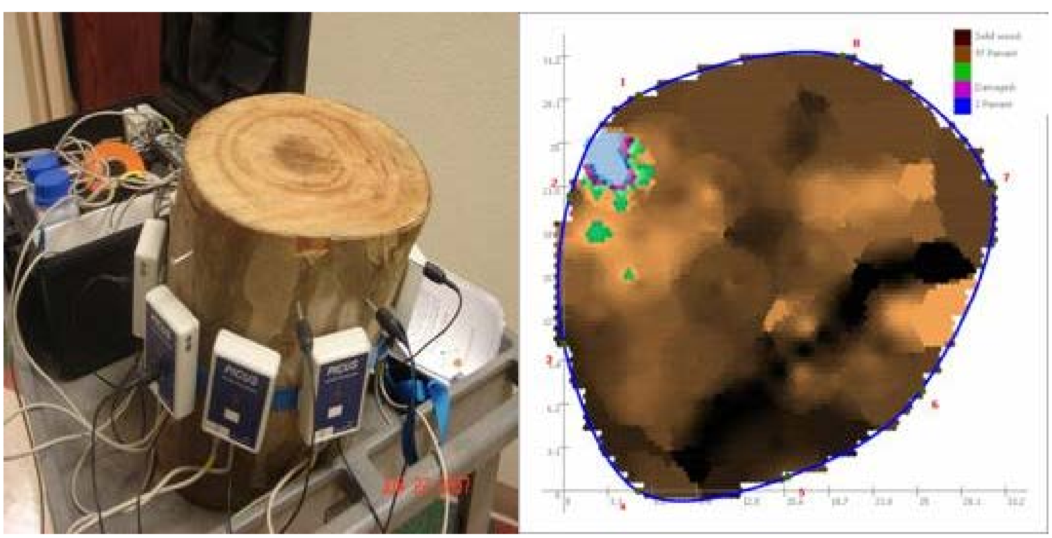
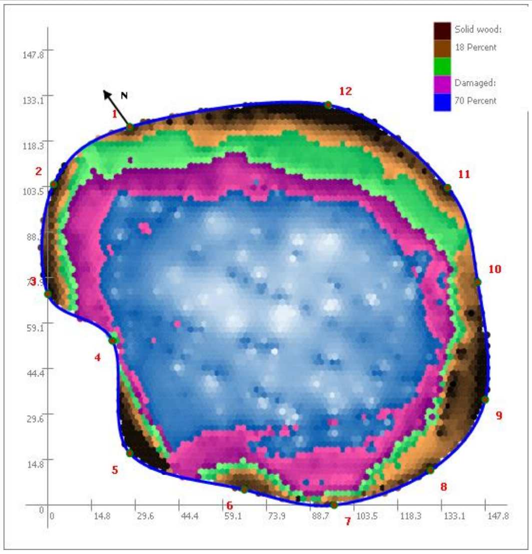
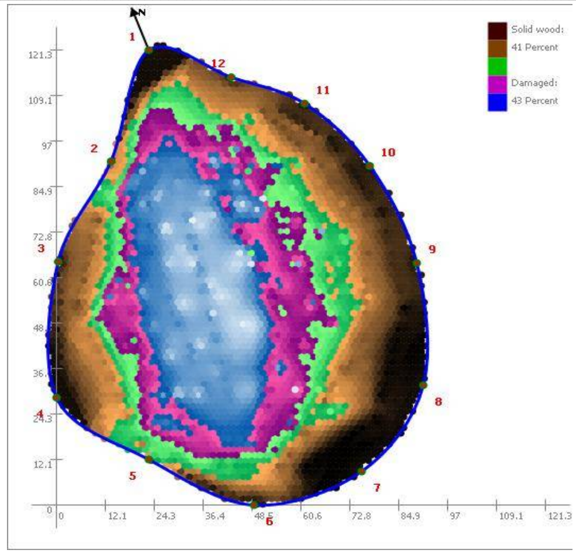


Figure 2. Another example of a test stump, showing 97% of the wood is solid (brown and black colors, 2% wood is damaged (blue/puple), and 1% of the wood is weakened (in green color). The circumference of the stump is 84 cm.

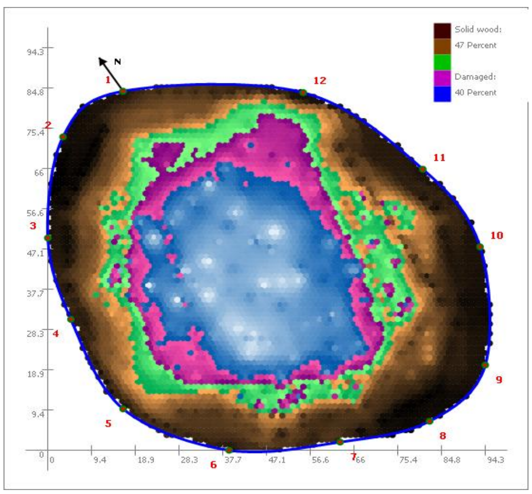
Figure 3. Example of root rot in water oak (top), and example of water oak tree uprooted by Hurricane Andrew (bottom).



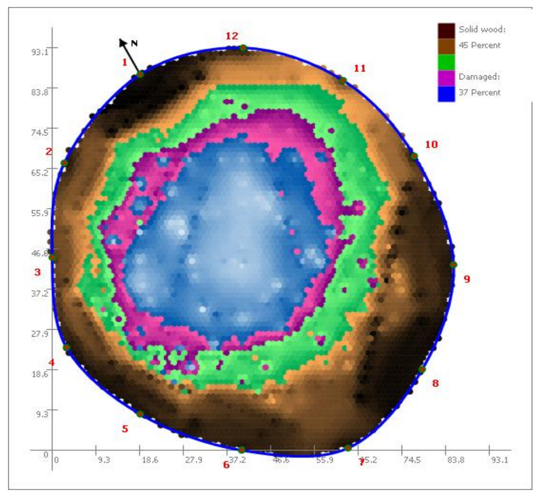
70% Decay at 15cm above ground



47% Decay at 80cm above the ground



40% Decay at 130cm above ground



37% Decay at 165cm above ground

Figure 4. Illustration of water oak trunk decay pattern using Tree ID #1 (pictured in the bottom left), showing the two dimension (2-D) cross-sectional tomography images measured at four levels (15, 80, 130, 165 cm above ground) and 3-D images constructed after combining all 2-D images in four different directions.